2020

The Effectiveness of Long-distance Translocation of Eastern Diamondback Rattlesnakes (Crotalus Adamanteus)

Allison Grace Kelley
kelley170@marshall.edu

THE EFFECTIVENESS OF LONG-DISTANCE TRANSLOCATION OF EASTERN DIAMONDBACK RATTLESNAKES (*CROTALUS ADAMANTEUS*)

A thesis submitted to
the Graduate College of
Marshall University
In partial fulfillment of
the requirements for the degree of
Master of Science
In
Biological Sciences
by
Allison Grace Kelley
Approved by
Dr. Jayme Waldron, Committee Chairperson
Dr. Shane Welch
Dr. Anne Axel

Marshall University
August 2020

PPROVAL OF THESIS

We, the faculty supervising the work of Allison Grace Kelley, affirm that the thesis, *The Effectiveness of Long-Distance Translocation of Eastern Diamondback Rattlesnakes (*Crotalus adamanteus*)*, meets the high academic standards for original scholarship and creative work established by the Biological Sciences Program and the College of Science. This work also conforms to the editorial standards of our discipline and the Graduate College of Marshall University. With our signatures, we approve the manuscript for publication.

		12 June 2020
Dr. Jayme Waldron, Department of Biological Sciences	Committee Chairperson	Date
		13 June 2020
Dr. Shane Welch, Department of Biological Sciences	Committee Member	Date
Anne C. Axel		19 June 2020
Dr. Anne Axel, Department of Biological Sciences	Committee Member	Date

ACKNOWLEDGMENTS

This thesis is the product of many hours of work and I could not have completed it alone. First, I would like to express my sincere gratitude to my advisor Dr. Jayme Waldron for her support, patience, and expertise; her guidance was invaluable. My other committee members, Dr. Shane Welch and Dr. Anne Axel, also provided valuable mentorship and helped me become a better scientist. I would also like to thank John Holloway and the other natural resources staff on Parris Island for their support, advice, and compelling lunch-time conversation. Thank you to April Atkinson and Will Dillman of the SCDNR for their encouragement and assistance. Special thanks to Emily Mausteller and Andy Day for assistance with field work. I also need to thank my fellow herp lab members Alex Foote, Nicholas Bolin, Liz Johnson, John Huang, Emily Mausteller, and honorary herp lab members Brynn Harshbarger and Katie Biggert, for their friendship and support. I could not have done this without you. Lastly, I would like to thank my parents, Jan and Kevin Kelley, for always encouraging my curiosity and gracefully tolerating all the animals, dead or alive, I brought into the house as a child. Thank you all.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Translocations have the potential to aim conservation efforts as well as to reduce mortality caused by human activities. Eastern diamondback rattlesnakes (*Crotalus adamanteus,* EDB) have a limited ability to adapt to habitat loss and fragmentation due to the species' slow life history and minimal dispersal ability. Because they are a venomous species, they are viewed as nuisance animals and are often killed on sight. We translocated a cohort of EDBs to investigate the potential of using translocations as a conservation and mitigation tool for this species. In July 2018, we translocated twelve adult eastern diamondback rattlesnakes from Parris Island Marine Corps Recruit Depot to an inland wildlife management area. We radio-located the rattlesnakes approximately three times weekly during the active season and once per week during the inactive season both pre- and post-translocation. We used these radio telemetry data to examine the effects translocation had on home-range size and average daily movement. We also used know-rate models to examine adult survival post-translocation. The post-translocation home ranges were larger than the pre-translocation home ranges and the snakes moved more on average per day post-translocation. We failed to detect an effect of translocation on two-year survival probability. We suspect that large post-translocation home ranges and average daily movements reflect the need to find suitable ambush and hibernacula sites, as well as the difference in coastal and inland woodland habitats. In order for translocations to be a viable conservation strategy for EDBs, more research is needed to determine the long-term viability of translocated populations.

THE EFFECTIVENESS OF LONG-DISTANCE TRANSLOCATION OF EASTERN DIAMONDBACK RATTLESNAKES (*CROTALUS ADAMANTEUS*)

INTRODUCTION

Translocation is the anthropogenic movement of animals from one area to another (IUCN 2013) and can be further divided into two types. A conservation translocation is when the primary objective of the movement is to aid conservation efforts (IUCN 2013). Translocations have been used as a conservation strategy for a wide variety of taxa (Germano et al. 2014, Goldenberg et al. 2019, Seddon et al. 2007) and have the potential to supplement declining or at-risk populations and enhance population viability or establish new populations in areas where the species has been extirpated (Germano et al. 2014, Dodd and Seigel 1991, IUCN 2013). For example, translocations have been implemented to supplement small, existing populations of black-tailed prairie dogs (*Cynomys ludovicianus*) decimated by disease (Dullum et al. 2005), as well as to augment declining populations of the federally endangered red-cockaded woodpecker (*Picoides borealis*; Herbez et al. 2011, Saenz et al. 2002). Translocations have also been used to establish new populations of tuatara (*Sphenodon punctatus*) in areas where they have been extirpated (Jarvie et al. 2016).

Alternatively, a mitigation translocation is when the motive for moving the animals is to reduce mortality caused by human activities or to placate the members of a community who view those animals as problematic (IUCN 2013, Germano et al. 2015). This type of translocation is commonly used with large predators such as brown bears (*Ursus arctos*; Milligan et al. 2018) and grey wolves (*Canis lupus*; Bradley et al. 2005) in order to reduce conflicts with humans and livestock, although the effectiveness of these projects are debated (Germano et al. 2014). Mitigation translocations are also used as a non-lethal way to address human conflict with common nuisance species in urban and suburban areas (Beringer et al. 2002, Walter et al. 2010, Mosillo et al. 1999, Flockhart and Clarke 2017). For species with limited dispersal ability, translocations have been used to remove animals from development and construction sites to prevent accidental mortality (Dickson et al. 2019, Rathbun and Schneider 2001, Ashton and Burke 2007).

Translocation studies are often taxonomically biased towards mammals and birds (Germano and Bishop 2009, Seddon et al. 2005) and as such, herpetofauna are often overlooked. This bias is further exacerbated by the secretive and cryptic nature of many reptiles and amphibians, which makes them difficult to study (Boback et al. 2020, Pike et al. 2008). The life history traits of snakes, in particular, place them at greater risk of extinction (Waldron et al. 2013, McKinney 1997), making conservation and mitigation actions, such as translocation, necessary. For example, many snake species exhibit limited dispersal ability and strong habitat specificity, making them susceptible to extirpation due to rapid landscape change (Waldron et al. 2013). Some of these same traits make snakes appropriate models for studying the effectiveness of translocation. Because of their low dispersal ability, snakes are less able to 'home' and return to their capture site, a commonly cited problem among translocation studies (Mengak 2018, Bradley et al. 2005, Milligan et al. 2018). Additionally, snakes are mainly solitary animals so they can be moved individually, unlike some mammals and birds that greatly benefit from entire family groups being translocated together (Bradley et al. 2005, Goldenberg et al. 2019).

Despite having great potential, the effectiveness and suitability of snake translocations for either conservation or mitigation purposes is not clear (Dodd and Seigel 1991, Ewen et al. 2014, Germano et al. 2014, Sullivan et al. 2015, Germano and Bishop 2009). Most previous snake translocation studies indicated that translocated snakes experienced lower survival than resident snakes (Devan-Song et al. 2016, Wolfe et al. 2018, Roe et al. 2010, Plummer and Mills 2000). Translocated *Nerodia sipedon* were reported to have an annual survival rate of 19.6%, compared to 45% for residents; this was attributed to the extensive movements of the translocated individuals but was not identified as reason to discount translocation as a potential conservation tool for the species (Roe et al. 2010). Similarly, translocated *Trimeresurus albolabris* had an annual survival probability of 4.2% compared to 16.5% for resident snakes, possibly because species with naturally low survival probabilities may be more negatively affected by translocation (Devan-Song et al. 2016). In contrast, there are examples of translocations where effects on survival were minimal (DeGregorio et al. 2017, Waldron et al. unpublished data). For instance, no mortality was observed among wild translocated *Pantherophis obsoletus* (DeGregorio et al. 2017).

It is well documented that translocation causes abnormal movement patterns such as more frequent unidirectional movements (Devan-Song et al. 2016, Reinert and Rupert 1999, Plummer and Mills 2000), more time spent moving (Reinert and Rupert 1999, Wolfe et al. 2018), and larger-than-normal home ranges (Roe et al. 2010, Waldron et al. unpublished data) compared to resident snakes. For example, activity ranges, mean distances moved per day, and maximum range lengths were found to be between 3 and 5 times larger for translocated *Crotalus horridus* compared to resident snakes, and translocation was not recommended for this species because of high mortality and aberrant behavior (Reinert and Rupert 1999). Additionally, some studies have reported higher average daily movement or mean distance moved for translocated individuals compared to residents (Roe et al. 2010, Reinert and Rupert 1999, Butler et al. 2005). Translocated *Notechis scutatus* travelled more than twice as far as residents between successive locations (Butler et al. 2005). Other studies found no difference in average daily movement between translocated and resident individuals (Wolfe et al. 2018) or greater average daily movements only for females (Devan-Song et al. 2016). Similarly, the effect of translocation on reproduction has not been thoroughly reported. Most translocation studies do not mention reproduction at all, and those that do differ in outcome with some reporting a great disruption in physiological reproductive activity (Devan-Song et al. 2016) and others reporting normal reproductive behaviors including parturition and courting (Reinert and Rupert 1999).

In order to resolve some of these discrepancies, we conducted a translocation study of eastern diamondback rattlesnakes (*Crotalus adamanteus*), a specialist of the longleaf pine savanna ecosystem. This species has undergone major population declines due to habitat loss and fragmentation (Martin and Means 2000, Timmerman and Martin 2003) and is currently being reviewed for federal protection under the Endangered Species Act (United States Fish and Wildlife Service 2012, IUCN 2011). Eastern diamondback rattlesnakes (EDB) are characterized by a slow life history that includes high longevity, high adult survival, and delayed maturation (Waldron et al. 2013). They also exhibit a limited dispersal ability, especially among mature adults, which feature high spatial fidelity (Waldron et al. 2013). These factors together suggest that EDBs have a limited ability to adapt to the severe habitat loss and fragmentation of the LLP ecosystem, are vulnerable to declines (Waldron et al. 2013, 2006) and may benefit from conservation translocations. Translocating individuals from small habitat fragments to larger areas of better quality habitat could supplement existing populations (Germano and Bishop 2009, Germano et al. 2014). Also, eastern diamondback rattlesnakes are a venomous species, and are therefore considered problematic by the public. The attitude encapsulated by the adage “the only good snake is a dead snake” is all too common, especially in areas where venomous species are prevalent (Pandey et al. 2016, Nonga and Haruna 2015). Mitigation translocations, moving individuals away from areas with large human populations, have the potential to mollify the public in a way that does not involve killing the snakes. Thus, EDBs provide a suitable model for studying the utility of translocation as both a conservation and mitigation strategy for a long-lived pit viper.

In this study, we translocated a cohort of 12 adult EDBs that had been radio telemetrically monitored at the donor site, allowing us to compare pre- and post-translocation movement patterns. We expected that the post-translocation home ranges would be larger than the pre-translocation home ranges. We also expected the snakes to have larger average daily movements post-translocation as they adapt to their new environment. Lastly, we expected translocation to negatively impact survival as compared to non-translocated snakes but despite this, we expected to detect reproductive effort. The outcome of this study will aid in our understanding of the effects translocation has on rattlesnakes and the suitability of translocation as both a conservation and mitigation strategy.

METHODS

Study Species

The eastern diamondback rattlesnake (*Crotalus adamanteus*) is the largest species of rattlesnake (Klauber and McClung 1972). It is endemic to pine savannas and woodlands of the imperiled longleaf pine ecosystem in the southeastern Coastal Plain, USA (Martin and Means 2000). Anthropogenic habitat loss has, in part, led to recent declines of EDBs across their historic range and they are currently being reviewed for federal protection under the Endangered Species Act (Waldron et al. 2008; 2013, Martin and Means 2000). This species is characterized by slow life history traits such as delayed maturation, high longevity, and high adult survival (Waldron et al. 2013). Adult EDBs rarely disperse at the landscape scale and survival is low among neonates, which do disperse (Waldron et al. 2006, Waldron et al. 2013). Due to the species' slow life history and limited dispersal ability, eastern diamondback rattlesnakes have a limited ability to adapt to habitat loss and fragmentation (Waldron et al. 2013).

Study Sites

Our source population came from Parris Island Marine Corps Recruit Depot (MCRDPI) located in Beaufort County, SC. Parris Island is a sea island of approximately 8,000 ha that includes residential areas, military recruit training areas, office buildings, and a public golf course. A large part of the island is coastal marsh habitat, and thinning practices and fire management are used in an attempt to keep a relatively open canopy in forested areas. The EDB population on the island has been monitored since 2008 with the goal of reducing EDB/recruit interactions.

State-owned properties located in Hampton and Jasper Counties, SC, were used as the recipient sites for the translocated EDBs. The property that served as the release site is 2373 ha in size and is bordered by two other state-owned properties, sized 2734 ha and 5374 ha, respectively. These properties contain a variety of habitats including fire-managed longleaf pine savanna, oak-hickory mixed-pine hardwoods, and the cypress-tupelo swamp forests of the Savannah River floodplain. Fire is used on all three properties to manage pine savannas and woodlands and the faunal species that depend on them such as EDBs, the gopher frog (*Lithobates capito*), and the federally endangered red-cockaded woodpecker (*Leuconotopicus borealis*).

Translocation and Radio Telemetry

Since 2008, EDBs on the MCRDPI have been monitored using radio telemetry and mark-recapture surveys. Those tracked using radio-telemetry were located approximately 2-3 times weekly during the active season (Apr - Nov) and once weekly during the inactive season (Dec - Mar). Each time a snake was located, they were considered to have moved if they were more than 4 meters away from their previous location. We used this approach to account for GPS-unit error (Trimble Juno 3B; 3-4m). The translocated individuals used in this study had been previously captured on the island and tracked for at least 200 days prior to being translocated. Individuals that had been radio-tracked for at least two consecutive years on MCRDPI were selected as non-translocated, control snakes. The non-translocated (control) snakes were not tracked during the same years as the translocated snakes. Each individual was equipped with an internal Holohil Systems SI-2 radio transmitter (11-13g) surgically implanted by a veterinarian following procedures modified from Reinert and Cundall (1982). Over the course of the study, each snake was captured at least twice yearly (once in the fall before ingress, and once immediately following egress) to monitor body condition. We processed snakes using a snake hook and clear restraining tubes and measured snout-to-vent length (SVL; cm), total length (TL; cm) and mass (g).

In July 2018, we translocated 12 adult EDBs from MCRDPI to the recipient property. We released individuals in quality EDB habitats, based on previous radio telemetry and mark-recapture data collected at the release site. We radio-located translocated snakes daily for one week post-release to ensure no individuals were lost if they made large initial movements. From then on, we located each snake at least three times weekly during the active season and once weekly during the inactive season.

Statistical Analysis

We conducted our analyses on data collected prior to translocation and one year post-translocation. All statistical analyses were conducted in SAS 9.4 unless otherwise stated.

Variables were log-transformed, if needed, to meet normality assumptions. We excluded one male snake from movement analyses because it disappeared shortly after being released at the recipient site and its fate was unknown. We constructed 95% minimum convex polygons (MCP) that represented the home ranges of each individual, using GPS location fixes after removing any obviously erroneous points. The 95% MCP excludes the 5% most outlying points thus excluding any occasional exploratory movements outside the true home range (Butler et al. 2005). We constructed pre-translocation home ranges using the Home Range Tools 2.0 extension in ArcMap 10.4.1 from location fixes on the MCRDPI obtained in the year leading up to the translocation. We created post-translocation home ranges from those location fixes obtained on the recipient site during the year following translocation. We also calculated two, consecutive-year home ranges for 10 adult, non-translocated EDBs on MCRDPI that had been monitored using radio-telemetry as part of a long-term monitoring project on the island. We used analysis of variance (ANOVA; PROC MIXED) to compare home-range size by treatment (translocated or non-translocated), year, and their interaction. We included an interaction statement because we expected translocated snakes would have larger home ranges during the second year of the study as compared to control snakes. We ran a post-hoc simple effects test to test the effect of year at both treatment levels.

To calculate the average daily movement for each snake, we combined consecutive points where the second point was recorded as being the same (< 4 m) as the first, accounting for any GPS error. We divided the total distance traveled (m), calculated using Home Range Tools 2.0 in ArcMap, by the number of days tracked pre- or post-translocation. We also calculated average daily movement for two consecutive years from the control group of 10 adult EDBs on MCRDPI. We used analysis of variance (ANOVA; PROC MIXED) to compare average daily movement by treatment (translocated or non-translocated), year, and their interaction. We included an interaction statement because we expected translocated snakes would move greater distances during the second year of the study as compared to control snakes. We ran a post hoc simple effects test to test the effect of year at both treatment levels.

Because not all the snakes were tracked for a full year prior to translocation, we investigated the effect of translocation on home-range size and average daily movement using only a subset of points. All translocated snakes were tracked for a minimum of 204 days prior to translocation, from December 8, 2017 to June 29, 2018. We calculated the pre-translocation home ranges again using only the location fixes from this date range and then calculated the post-translocation home ranges using location fixes from the same date range of the next year, Dec. 8, 2018 through June 29, 2019. We also calculated two, consecutive-year home ranges for the control snakes using only points collected between Dec. 8th and June 29th of each year. We used analysis of variance (ANOVA; PROC MIXED) to compare home-range size by treatment (translocated or non-translocated), year, and their interaction. We then calculated the average daily movements for the date subset in the same manner and analyzed with a two-way ANOVA. We excluded three translocated snakes from this analyses that died early into or before the December 8th - June 29th subset and one control snake that had <10 location fixes during the first year date subset.

We used radio-telemetry data to conduct known-fate survival analysis in program MARK 9.0 (White and Burnham 1999) using data collected during the year following translocation. We collapsed all radio-telemetry data into 12, one-month intervals and created an encounter history with 12 entries per snake. One individual was moved to the recipient site approximately three weeks later than the rest of the cohort because it was unable to be captured at the source site. We deemed any effect of this to be negligible and started that encounter history on the same date as the other individuals. We modeled survival as a function of sex, size (snout-to-vent length, SVL) and body condition. Body condition was calculated from the residuals of an ordinary least-squares regression of body mass predicted by SVL, such that positive values indicated high relative body condition and negative values indicated low relative body condition (Jakob et al. 1996). We also modeled survival over two seasons (active and inactive) based on EDB activity patterns. We coded the active season as Apr-Nov, which encompassed EDB foraging and breeding seasons. We coded the inactive season as Dec-March, when EDBs were inactive and regularly occupied subterranean habitats. These season delineations were based on observations of telemetered EDBs within the study area since 2008. We constructed five candidate models that included survival as a constant (S(.)), as a function of the individual covariates (S(Cov)), and varying by season (S(season)). We used Akaike's Information Criterion adjusted for small sample size (AIC_c) to rank candidate models. We estimated annual survival from the constant model.

We used a separate known-fate survival analysis to compare two-year survival between translocated and non-translocated individuals. We randomly selected 18 non-translocated individuals that had been tracked and survived on MCRDPI for at least one year between 2010 and 2019. We selected snakes that had been tracked for a full year because the translocated snakes had 100% survival in the first year (pre-translocation). For both the translocated and non-translocated snakes, we collapsed all radio-telemetry data into 24, one-month intervals and created an encounter history with 24 entries per snake. We modeled survival as a function of treatment (translocated or non-translocated) and calculated the two-year survival probability for both by designating specific covariate values.

RESULTS

Home-Range Size

The average pre-translocation home-range size was 14.52 ± 3.09 ha (SE) and the average post-translocation home-range size was 44.77 ± 9.92 ha, whereas the average home-range sizes for the control snakes for two consecutive years were 16.06 ± 4.49 ha and 24.99 ± 9.38 ha (Table 1). We expected a significant interaction of treatment and year, which would indicate larger home-range size for the translocated group in the second year. The treatment by year interaction approached significance ($F_{1,19} = 4.03$, $p = 0.0591$; Table 2), such that translocated snake home ranges were larger in year two (Figure 1). We failed to detect a main effect of treatment on home-range size ($F_{1,19} = 1.79$, $p = 0.20$). Home-range size differed by year; year 2 home ranges were larger than year 1 home ranges ($F_{1,19} = 17.78$, $p = 0.0005$; Table 2). A test of simple effects revealed a significant effect of year on the translocated group ($F_{1,19} = 20.34$, $p = 0.0002$) and no effect of year on the control group ($F_{1,19} = 2.33$, $p = 0.1436$). There was a large amount of variation in home-range size, especially for the translocated group. When we limited our analysis to a subset of points representing the minimum number of days that all snakes were tracked on MCRDPI (Table 1), we failed to detect a main effect of year ($F_{1,16} = 3.2$, $p = 0.0924$), treatment ($F_{1,16} = 0.17$, $p = 0.6829$), or the treatment by year interaction ($F_{1,16} = 0.09$, $p = 0.765$) on home-range size.

Table 1. Mean 95% minimum convex polygon home-range estimates (ha) for translocated and non-translocated (control) snakes. 'Subset' indicates groups where only location fixes generated between Dec. 8th and June 29th were used to calculate home ranges.

GROUP	N	MEAN HRS (HA)	SE	RANGE
Translocated Year 1	11	14.62	3.09	2.57 – 34.06
Translocated Year 2	11	44.77	9.92	8.57 – 122.83
Control Year 1	10	16.06	4.49	1.24 – 40.33
Control Year 2	10	24.99	9.38	4.66 – 101.71
Subset Translocated Year 1	9	7.80	1.67	2.57 – 16.00
Subset Translocated Year 2	9	12.65	3.67	4.49 – 38.88
Subset Control Year 1	9	6.50	1.61	1.28 – 17.77
Subset Control Year 2	9	18.75	9.49	0.65 – 91.24

Table 2. Differences of least squares means from home-range size (ha) ANOVA. Shaded rows have significance at alpha = 0.05. DF = 19 for all rows.

EFFECT	TREATMENT	YEAR	TREATMENT	YEAR	ESTIMATE	SE	T	P - VALUE
Year		1		2	-0.3371	0.0800	-4.22	0.0005
Treatment	C		T		-0.2006	0.1501	-1.34	0.1971
Treatment*Year	C	1	C	2	-0.1766	0.1157	-1.53	0.1436
Treatment*Year	C	1	T	1	-0.0401	0.1701	-0.24	0.8163
Treatment*Year	C	1	T	2	-0.5378	0.1701	-3.16	0.0051
Treatment*Year	C	2	T	1	0.1365	0.1701	0.80	0.4320
Treatment*Year	C	2	T	2	-0.3612	0.1701	-2.12	0.0470
Treatment*Year	T	1	T	2	-0.4977	0.1104	-4.51	0.0002

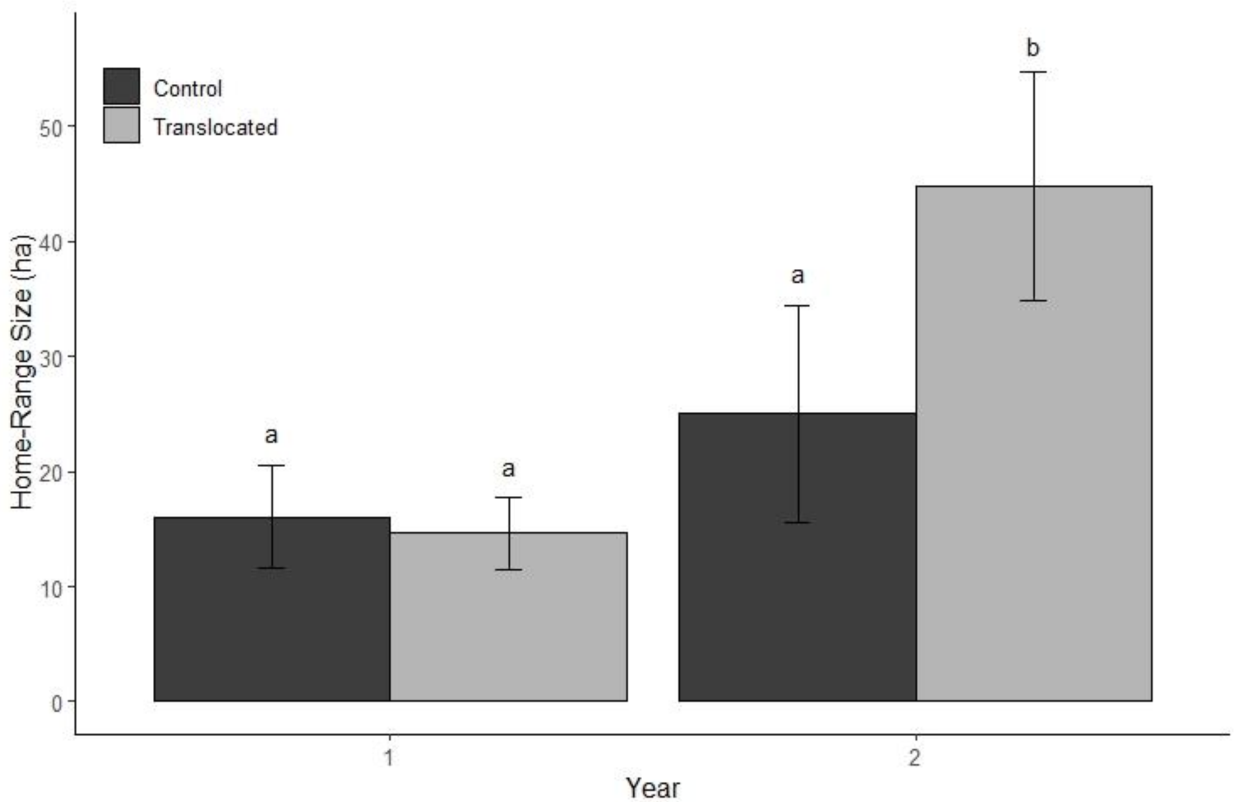

Figure 1. Mean home-range size (ha) for the translocated and non-translocated (control) groups over two years. Error bars show standard error and the letters designate significance at $\alpha = 0.05$ based on the differences of the least square means from the two-way, repeated measures ANOVA.

Average Daily Movement

The average distance moved per day was 9.86 ± 1.2 m (SE) prior to translocation and 21.4 ± 2.79 m after being translocated (Table 3). Control snakes moved 11.77 ± 2.28 m per day in the first year and 10.69 ± 1.18 m the second year (Table 3). We failed to detect an effect of treatment on average daily movement ($F_{1,19} = 2.37$, $p = 0.1403$). Average daily movement differed by year such that year 2 had greater daily movements than year 1 ($F_{1,19} = 14.47$, $p = 0.0012$). We expected a significant interaction of treatment and year, which would indicate greater daily movements for the translocated group in the second year. The treatment by year interaction was significant ($F_{1,19}$ = 15.81, p = 0.0008) such that translocation led to higher average daily movements for year 2 (Figure 2). The simple effects test showed that year had a significant effect on the translocated group ($F_{1,19}$ = 31.77, p <0.0001) and no effect on the control group ($F_{1,19}$ = 0.01, p = 0.9066). When we limited our analysis to December – June subset of points (Table 3), we failed to detect a main effect of year ($F_{1,16}$ = 3.22, p = 0.09), treatment ($F_{1,16}$ = 1.09, p = 0.3121), or the treatment by year interaction ($F_{1,16}$ = 0.11, p = 0.7452) on home-range size.

Table 3. Average daily movement (m) for translocated and non-translocated (control) snakes. 'Subset' indicates groups where only location fixes generated between Dec. 8th and June 29th were used to calculate home ranges.

GROUP	N	MEAN ADM (M)	SE	RANGE
Translocated Year 1	11	9.86	1.20	3.09 – 16.84
Translocated Year 2	11	21.40	2.79	11.61 – 37.31
Control Year 1	10	11.77	2.28	4.90 – 28.06
Control Year 2	10	10.69	1.18	5.33 – 15.41
Subset Translocated Year 1	9	7.81	1.02	3.21 – 11.74
Subset Translocated Year 2	9	8.90	1.07	4.03 – 14.29
Subset Control Year 1	9	6.26	1.04	3.40 – 14.13
Subset Control Year 2	9	7.87	1.10	1.81 – 13.65

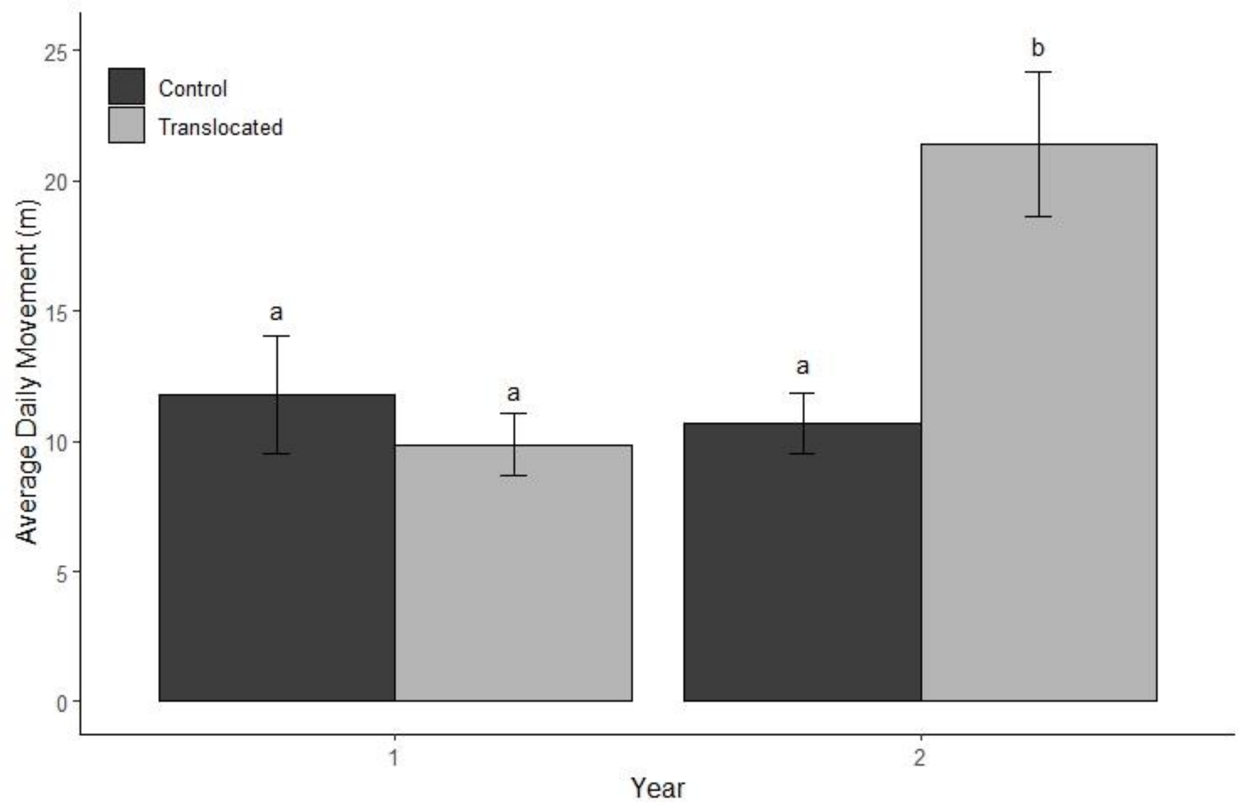

Figure 2. Mean average daily movement (m) for the translocated and non-translocated (control) groups over two years. Error bars show standard error and the letters designate significance at $\alpha = 0.05$ based on the differences of the least square means from the two-way, repeated measures ANOVA.

Survival

One year post-translocation, five (4 males and 1 female) translocated EDBs died. Cause of death varied and included starvation (N=1), attempted predation by a bird (N=1), killed by humans (N=2), and unknown (N=1). Only non-correlated covariates variables were included as covariates in the models. Known-fate survival models (Table 4) failed to detect significant covariate effects (95% confidence limits of regression coefficients contained zero) on adult survival. Based on the constant model, annual survival probability post-translocation was 61 ± 13% (estimate ± SE).

Table 4. Candidate known-fate models used to examine translocated EDB survival. ΔAIC_C = the difference between the AIC_C value for the current model and the lowest AICc score; K = number of model parameters. Models are listed in order of support. SVL = snout-vent-length (cm), 2season = active or inactive seasons, BCI = body condition index.

MODEL	AIC_C	DELTA AIC_C	WEIGHT	K
{S(.)}	43.94	0.00	0.35	1
{S(SVL)}	45.11	1.17	0.20	2
{S(SEX)}	45.16	1.23	0.19	2
{S(2SEASON)}	45.89	1.96	0.13	2
{S(BCI)}	45.96	2.03	0.13	2

We failed to detect an effect of treatment on two-year survival probability (β = -0.333 ± 0.638, 95% CI = -1.583 – 0.916). The two-year survival probability was 64 ± 13% for the translocated snakes and 72 ± 10% for the non-translocated snakes.

DISCUSSION

Translocation affected EDB movement but unexpectedly did not affect two-year survival probability. The significant interaction between treatment and year on average daily movement shows that EDBs exhibited greater average daily movement post-translocation, which is in accordance with other snake translocation studies (Roe et al. 2010, Reinert and Rupert 1999, Butler et al. 2005). An increase in average daily movement due to translocation has also been observed with *Crotalus horridus*; those translocated snakes moved an average of 96 m per day whereas resident snakes moved an average of 26 m per day (Reinert and Rupert 1999). In this study, EDBs averaged 21 ± 9 m per day post-translocation which is similar to a previous EDB translocation study where snakes moved an average of 25 ± 11 m per day post-translocation (Jungen 2018). A typical average distance moved per day for inland EDBs is 16.5 m (Timmerman 1995), which was greater than the first-year averages of our translocated and non-translocated snakes (9.9 m and 11.2 m, respectively). The overall smaller average daily movements on MCRDPI are likely a result of the relatively small size and large human population of their island source site; the EDBs restrict their movements to low-risk areas with low human activity resulting in smaller-than-normal daily movements (Waldron et al. 2012). The increase in movement we observed is likely indicative of a stress response to translocation (Heiken et al. 2016, Teixeira et al. 2007), as well as the need to explore their new environment to find suitable ambush and hibernacula sites (Butler et al. 2005, Reinert and Rupert 1999). Other studies found that after being released at the recipient site, the snakes made large movements very quickly, perhaps in an attempt to relocate their original home ranges (Reinert 1991, Waldron et al. unpublished data). However, the snakes in this study barely moved from their release site for the first week post-translocation, and we observed no obvious unidirectional movements indicative of homing.

We failed to detect an effect of treatment (translocated or non-translocated) by year interaction on home-range size, although it approached significance. We suggest this lack of effect is due to large amounts of variation, mainly in the translocated group. It has been suggested that some amount of change in home-range size between years is to be expected due to fluctuating seasonal changes in habitat productivity (Timmerman 1995). The strong effect of year we detected is likely due to such fluctuation. Despite the lack of a significant effect of the treatment by year interaction, all specific combinations of differences in the least square means that include treatment year 2 (the post-translocation year) are significant at the 0.05 level (Table 2). This demonstrates that translocation likely did influence home-range size, but it is partially obscured by large amounts of variation and limited power. Both translocated and control snakes had larger home ranges in year 2; on average, translocated snakes exhibited a greater increase in home-range size compared to control snakes. Additionally, the home-range size simple effects test demonstrated that translocated snakes had larger home ranges post-translocation. Many snake translocation studies have reported larger home ranges due to translocation (Wolfe et al. 2018, Roe et al. 2010, Reinert and Rupert 1999, Butler et al. 2005, DeGregorio et al. 2017). Translocated *Crotalus horridus*, a closely related species, had convex polygon home ranges ranging from 233 ha (female mean) to 600 ha (male mean) whereas the home ranges of resident individuals ranged from 42 ha (female mean) to 60 ha (male mean; Reinert and Rupert 1999). Among inland populations, EDB home ranges generally range from 29 to 89 ha for females and 85 to 160 ha for males (Waldron et al. 2006, Timmerman 1995) whereas average EDB home ranges on our source site, MCRDPI, were 5.3 ha for females and 12.0 ha for males (Waldron et al. 2012). The overall smaller home-range size on MCRDPI is again likely an effect of the small size and large human population of the island (Waldron et al. 2012).

We failed to detect significant covariate effects on annual survival probability (Table 4), likely reflecting our small sample size and limited power. Annual post-translocation survival was 61 ± 13% (estimate ± SE, based on the constant model). Annual survival probability of EDBs at the source population was 86 ± 4% (Waldron and Welch 2017) and 82 ± 6.5% at the recipient site for non-translocated resident individuals (Waldron et al. 2013). Despite an apparent effect on annual survival probability, the two-year survival probability for the translocated snakes (64 ± 13%) was not significantly different from that of non-translocated snakes (72 ± 10%) indicating that translocation may not have a negative effect on the survival of this species.

Of the five individuals that died within one-year post translocation, the causes of death varied greatly. Despite the recipient site having low human traffic, two of the five deaths were caused by humans. We believe this demonstrates how negative attitudes towards snakes, especially venomous species, can hinder conservation progress. As long as the public endorses the attitude "the only good snake is a dead snake," conservation and mitigation programs, such as translocations, are only temporary solutions to a much larger problem. Snakes are often viewed as dangerous due to cultural norms and phobias (Nonga and Haruna 2015, Pandey et al. 2016, Keener-Eck et al. 2020) and the direct killing of snakes by humans has been cited as a factor in population declines (Gibbons et al. 2000, Whitaker and Shine 2000). Venomous species are especially likely to be affected by peoples' negative attitudes; 49% of survey respondents in Nepal would kill any venomous snake encountered (Pandey et al. 2016). However, there is hope through education. For example, a person's behavior in reaction to a timber rattlesnake encounter is guided by knowledge and past experiences, and snake encounters with positive outcomes lead to more positive and harder to change attitudes (Keener-Eck et al. 2019). We recommend the implementation of education programs among school-aged children to inform and expose them to snakes, in order to replace fear with knowledge (Morgan and Gramann 1989). Conservation and mitigation programs, such as translocations, are more likely to succeed if the public is accepting of snakes and their role in the ecosystem.

Our results may have been affected by variation in the length of time telemetered EDBs were monitored prior to being translocated. Ideally, we would have only translocated snakes that had been radio-telemetrically monitored for a full year prior to being moved. Unfortunately, this was not possible due to limited sample size, and only 5 out of 12 EDBs in our study were tracked for a full year. All snakes in our study were tracked for a minimum of 204 days prior to translocation, and all were monitored from December through June. Thus, we compared home-range sizes and average daily movements for that subset of dates and found that year did not affect the treatment groups (translocated or non-translocated) differently for both home-range size and average daily movement. While these results were not anticipated, we suspect our limited power affected our ability to detect an effect of translocation on movement. We suspect these results could be due to low power; we excluded three snakes because they died before or early into the December 8th – June 29th subset. Additionally, this date subset excludes some of the foraging season (Apr – Jul) and all of the breeding season (Aug – Nov; Waldron et al. 2013). The fact that we failed to detect a difference in either home-range size or average daily movement for the December to June subset is also likely an effect of different EDB densities on the source and recipient sites. The density of EDBs on MCRDPI is higher than densities of typical inland sites, such as the recipient property (Waldron et al. unpublished data). When translocated, males would have had to move more in search of females on the recipient property than previously on MCRDPI. Because the December to June subset excluded all of the breeding season, the increase in movement due to lower EDB density would not be evident.

We suspect that habitat characteristics of both the source and recipient sites affected the success of EDB translocation. Eastern diamondback rattlesnakes are habitat specialists within the longleaf pine savanna but will select for other habitats that are structurally similar (Waldron et al. 2006, Martin and Means 2000). Our source site, MCRDPI, exemplifies an alternative habitat because the EDBs there rely on the coastal marsh habitat that makes up a large part of the island (Stohlgren 2013). Coastal marsh habitat is structurally similar to the longleaf pine savanna but is quite different in other ways including prey base, plant species composition, and hydrological characteristics (Chabreck 1988). Therefore, natal habitat preference induction (NHPI), where natal habitat molds an individual's habitat preference following dispersal (Davis and Stamps 2004, Davis 2008), may play a role in the success of EDB translocations. This theory states that aspects of individuals' phenotypes are shaped by the specific environment they are born into, making them especially well-suited for that habitat (Davis and Stamps 2004). Thus, when it comes time to disperse, it could be beneficial for individuals to select for a habitat similar to their natal habitat (Davis and Stamps 2004). In our study, we moved EDBs from an island with coastal marsh habitat to an inland site containing a variety of habitats including fire-managed longleaf pine savanna, oak-hickory mixed-pine hardwoods, and the cypress-tupelo swamp forests of the Savannah River floodplain. By moving them to a site with fire-managed longleaf pine savanna, we characterized the move as one from suitable habitat to very good habitat, thinking this would help control the expected increase in daily movement and home range size. It is possible that due to NHPI, the snakes were unable to cope with the dramatic change in habitat and experienced high amounts of stress, even though the change was for the better. Natal habitat preference induction could have been a factor in other snake translocation studies as well but it is hard to make that determination because many of these studies either do not describe the source sites (Roe et al. 2010), or obtained their study animals sporadically from many different areas (Wolfe et al. 2018, Devan-Song et al. 2016, DeGregorio et al. 2017).

We suggest that translocations have potential for mitigation and conservation uses but we caution against their casual use. We failed to detect a significant reduction in survival probability due to translocation and we observed typical reproductive behaviors. Two females gave birth post-translocation and several males were witnessed courting resident females. The increase in home-range size and average daily movements we observed post-translocation is concerning and demonstrates that stress may have a bigger effect on the behavior of the snakes than previously thought. These stress effects may be offset by reproductive activity, provided some of these offspring survive to adulthood. In a mitigation situation, we believe translocation can be used as an alternative to killing the snakes provided there is adequate planning involved because we saw no significant effect on two-year survival probability. However, we urge for more caution in conservation-based circumstances. More research is needed on the survivorship of the offspring of translocated snakes before translocation can be used as a reliable conservation strategy.

LITERATURE CITED

Ashton, K. G., and R. L. Burke. 2007. Long-Term Retention of a Relocated Population of Gopher Tortoises. The Journal of Wildlife Management 71:783-787.

Beringer, J., L. P. Hansen, J. A. Demand, J. Sartwell, M. Wallendorf, and R. Mange. 2002. Efficacy of Translocation to Control Urban Deer in Missouri: Costs, Efficiency, and Outcome. Wildlife Society Bulletin (1973-2006) 30:767-774.

Boback, S. M., M. G. Nafus, A. A. Y. Adams, and R. N. Reed. 2020. Use of visual surveys and radiotelemetry reveals sources of detection bias for a cryptic snake at low densities. Ecosphere 11:e03000.

Bradley, E. H., D. H. Pletscher, E. E. Bangs, K. E. Kunkel, D. W. Smith, C. M. Mack, T. J. Meier, J. A. Fontaine, C. C. Niemeyer, and M. D. Jimenez. 2005. Evaluating Wolf Translocation as a Nonlethal Method to Reduce Livestock Conflicts in the Northwestern United States. Conservation Biology 19:1498-1508.

Butler, H., B. Malone, and N. Clemann. 2005. The effects of translocation on the spatial ecology of tiger snakes (*Notechis scutatus*) in a suburban landscape. Wildlife Research 32:165-171.

Chabreck, R. H. 1988. Coastal Marshes: Ecology and Wildlife Management. University of Minnesota Press, Minneapolis, Minnesota, USA.

Davis, J. M., and J. A. Stamps. 2004. The effect of natal experience on habitat preferences. Trends in Ecology & Evolution 19:411-416.

Davis, J. M. 2008. Patterns of variation in the influence of natal experience on habitat choice. Quarterly Review of Biology 83:363-380.

DeGregorio, B. A., J. H. Sperry, T. D. Tuberville, and P. J. Weatherhead. 2017. Translocating ratsnakes: does enrichment offset negative effects of time in captivity? Wildlife Research 44:438-448.

Devan-Song, A., P. Martelli, D. Dudgeon, P. Crow, G. Ades, and N. E. Karraker. 2016. Is long-distance translocation an effective mitigation tool for white-lipped pit vipers (*Trimeresurus albolabris*) in South China? Biological Conservation 204:212-220.

Dickson, B. G., R. D. Scherer, A. M. Kissel, B. P. Wallace, K. M. Langin, M. E. Gray, A. F. Scheib, and B. Weise. 2019. Multiyear monitoring of survival following mitigation-driven translocation of a long-lived threatened reptile. Conservation Biology 33:1094-1105.

Dodd, C. K., and R. A. Seigel. 1991. Relocation, Repatriation, and Translocation of Amphibians and Reptiles: Are They Conservation Strategies That Work? Herpetologica 47:336-350.

Dullum, J. L. D., K. R. Foresman, and M. R. Matchett. 2005. Efficacy of Translocations for Restoring Populations of Black-Tailed Prairie Dogs. Wildlife Society Bulletin (1973-2006) 33:842-850.

Ewen, J. G., P. S. Soorae, and S. Canessa. 2014. Reintroduction objectives, decisions and outcomes: global perspectives from the herpetofauna. Animal Conservation 17:74-81.

Flockhart, D. T. T., and J. B. Clarke. 2017. Demographic consequences of translocation of overabundant Canada geese breeding in urban areas. Wildlife Society Bulletin 41:231-239.

Germano, J. M., and P. J. Bishop. 2009. Suitability of Amphibians and Reptiles for Translocation. Conservation Biology 23:7-15.

Germano, J. M., J. G. Ewen, H. Mushinsky, E. McCoy, and L. Ortiz-Catedral. 2014. Moving towards greater success in translocations: recent advances from the herpetofauna. Animal Conservation 17:1-3.

Germano, J. M., K. J. Field, R. A. Griffiths, S. Clulow, J. Foster, G. Harding, and R. R. Swaisgood. 2015. Mitigation-driven translocations: are we moving wildlife in the right direction? Frontiers in Ecology and the Environment 13:100-105.

Gibbons, J. W., D. E. Scott, T. J. Ryan, K. A. Buhlmann, T. D. Tuberville, B. S. Metts, J. L. Greene, T. Mills, Y. Leiden, S. Poppy, and C. T. Winne. 2000. The global decline of reptiles, deja vu amphibians. BioScience 50:653.

Goldenberg, S. Z., M. A. Owen, J. L. Brown, G. Wittemyer, Z. M. Oo, and P. Leimgruber. 2019. Increasing conservation translocation success by building social functionality in released populations. Global Ecology and Conservation 18: e00604.

Herbez, E. M., M. J. Chamberlain, and D. R. Wood. 2011. Using Adult Groups of Red-Cockaded Woodpeckers for Translocations and Population Augmentation. The Journal of Wildlife Management 75:1568-1573.

Heiken, K. H., G. A. Brusch, S. Gartland, C. Escallón, I. T. Moore, and E. N. Taylor. 2016. Effects of long distance translocation on corticosterone and testosterone levels in male rattlesnakes. General and Comparative Endocrinology 237:27-33.

IUCN (International Union for Conservation of Nature). 2011. Viper Specialist Group: Conservation action plan on the horizon. Species 53:32.du

IUCN (International Union for Conservation of Nature). 2013. Guidelines for reintroductions and other conservation translocations. Prepared by the IUCN/SSC Reintroduction and invasive species specialist groups' task force on moving plants and animals for conservation purposes. IUCN, Gland, Switzerland and Cambridge, UK.

Jakob, E. M., S. D. Marshall, G. W. Uetz. 1996. Estimating fitness: a comparison of body condition indices. Oikos 77: 61-67.

Jarvie, S., M. R. Recio, S. C. Adolph, P. J. Seddon, and A. Cree. 2016. Resource selection by tuatara following translocation: a comparison of wild-caught and captive-reared juveniles. New Zealand Journal of Ecology 40:13-20.

Jungen, M. T. 2018. Eastern diamondback rattlesnake (*Crotalus adamanteus*) telemetry techniques and translocation. Thesis, Marshall University, Huntington, USA.

Keener-Eck, L. S., A. T. Morzillo, and R. A. Christoffel. 2019. Resident attitudes toward timber rattlesnakes (*Crotalus horridus*). Society and Natural Resources doi: http://dx.doi.org/10.1080/08941920.2019.165989

Keener-Eck, L. S., A. T. Morzillo, and R. A. Christoffel. 2020. A comparison of wildlife value orientations and attitudes toward timber rattlesnakes (*Crotalus horridus*). Human Dimensions of Wildlife 25:47-61.

Klauber, L. M., and K. H. McClung. 1972. Rattlesnakes, their habits, life histories, and influence on mankind. University of California Press, Berkely, California, USA.

Martin, W. H., and D. B. Means. 2000. Distribution and habitat relationships of the eastern diamondback rattlesnake (*Crotalus adamanteus*). Herpetological Natural History 7:9-34.

McKinney, M. L. 1997. Extinction vulnerability and selectivity: Combining ecological and paleontological views. Annual Review of Ecology & Systematics 28:495.

Mengak, M. T. 2018. Wildlife translocation. Wildlife damage management technical series. USDA, APHIS, WS National Wildlife Research Center. Fort Collins, Colorado. 15p.

Milligan, S., L. Brown, D. Hobson, P. Frame, and G. Stenhouse. 2018. Factors affecting the success of grizzly bear translocations. The Journal of Wildlife Management 82:519-530.

Morgan, J. M., and J. H. Gramann. 1989. Predicting effectiveness of wildlife education programs: a study of students' attitudes and knowledge toward snakes. Wildlife Society Bulletin 17:501-509.

Mosillo, M., E. J. Heske, and J. D. Thompson. 1999. Survival and Movements of Translocated Raccoons in Northcentral Illinois. The Journal of Wildlife Management 63:278-286.

Nevil Amos, J., A. F. Bennett, R. M. Nally, G. Newell, A. Pavlova, J. Q. Radford, J. R. Thomson, M. White, and P. Sunnucks. 2012. Predicting Landscape-Genetic Consequences of Habitat Loss, Fragmentation and Mobility for Multiple Species of Woodland Birds. PLoS ONE 7:1-12.

Nonga, H. E., and A. Haruna. 2015. Assessment of human-snake interaction and its outcomes in Monduli District, northern Tanzania. Tanzania Journal of Health Research 17:1.

Pandey, D. P., G. S. Pandey, K. Devkota, and M. Goode. 2016. Public perceptions of snakes and snakebite management: implications for conservation and human health in southern Nepal. Journal of Ethnobiology & Ethnomedicine 12:2-24.

Pike, D. A., L. Pizzatto, B. A. Pike, and R. Shine. 2008. Estimating Survival Rates of Uncatchable Animals: The Myth of High Juvenile Mortality in Reptiles. Ecology 89:607-611.

Plummer, M. V., and N. E. Mills. 2000. Spatial Ecology and Survivorship of Resident and Translocated Hognose Snakes (*Heterodon platirhinos*). Journal of Herpetology 34:565-575.

Rathbun, G. B., and J. Schneider. 2001. Translocation of California Red-Legged Frogs (*Rana aurora draytonii*). Wildlife Society Bulletin (1973-2006) 29:1300-1303.

Reinert, H. K., and D. Cundall. 1982. An Improved Surgical Implantation Method for Radio-Tracking Snakes. Copeia 1982:702-705.

Reinert, H. K., and R. R. Rupert. 1999. Impacts of Translocation on Behavior and Survival of Timber Rattlesnakes, *Crotalus horridus*. Journal of Herpetology 33:45-61.

Reinert, H. K. 1991. Translocation as a Conservation Strategy for Amphibians and Reptiles: Some Comments, Concerns, and Observations. Herpetologica 47:357-363.

Roe, J. H., M. R. Frank, S. E. Gibson, O. Attum, and B. A. Kingsbury. 2010. No place like home: an experimental comparison of reintroduction strategies using snakes. Journal of Applied Ecology 47:1253-1261.

Saenz, D., K. A. Baum, R. N. Conner, D. C. Rudolph, and R. Costa. 2002. Large-Scale Translocation Strategies for Reintroducing Red-Cockaded Woodpeckers. The Journal of Wildlife Management 66:212-221.

Seddon, P. J., D. P. Armstrong, and R. F. Maloney. 2007. Developing the Science of Reintroduction Biology. Conservation Biology 21:303-312.

Seddon, P. J., P. S. Soorae, and F. Launay. 2005. Taxonomic bias in reintroduction projects. Animal Conservation 8:51-58.

Stohlgren, K. M. 2013. Eastern diamondback rattlesnake: using occupancy and population models to direct management. Thesis, The University of Georgia, Athens, USA.

Sullivan, B. K., E. M. Nowak, and M. A. Kwiatkowski. 2015. Problems with mitigation translocation of herpetofauna. Conservation Biology 29:12-18.

Teixeira, C. P., C. S. De Azevedo, M. Mendl, C. F. Cipreste, R. J. Young. 2007. Revisiting translocation and reintroduction programmes: the importance of considering stress. Animal Behaviour 73:1-13.

Timmerman, W. W., and W. H. Martin. 2003. Conservation guide to the eastern diamondback rattlesnake, Crotalus adamanteus. Society for the Study of Amphibians and Reptiles Herpetological Circular No. 32.

Timmerman, W. W. 1995. Home range, habitat use, and behavior of the eastern diamondback rattlesnake (*Crotalus adamanteus*) on the Ordway Preserve. Bulletin Florida Museum Natural History, 38: 127-158.

United States Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants: 90-day finding on a petition to list the eastern diamondback rattlesnake as threatened. Fed. Reg. 77, 27403-27411.

Waldron, J. L., and S. M. Welch. 2017. Marine Corps Recruit Depot, Parris Island (MCRDPI) Herpetofaunal Survey and Eastern Diamondback Rattlesnake (*Crotalus adamanteus*) Monitoring and Tracking. DOD Annual Report.

Waldron, J. L., S. H. Bennett, S. M. Welch, M. E. Dorcas, J. D. Lanham, and W. Kalinowsky. 2006. Habitat specificity and home-range size as attributes of species vulnerability to extinction: a case study using sympatric rattlesnakes. Animal Conservation 9:414-420.

Waldron, J. L., S. M. Welch, and M. D. Martin. 2012. Eastern Diamondback Rattlesnake Monitoring on the Marine Corps Recruit Depot Parris Island (MCRDPI). DOD Annual Report.

Waldron, J. L., S. M. Welch, and S. H. Bennett. 2008. Vegetation structure and the habitat specificity of a declining North American reptile: A remnant of former landscapes. Biological Conservation 141:2477-2482.

Waldron, J. L., S. M. Welch, S. H. Bennett, W. G. Kalinowsky, and T. A. Mousseau. 2013. Life history constraints contribute to the vulnerability of a declining North American rattlesnake. Biological Conservation 159:530-538.

Walter, W. D., M. J. Lavelle, J. W. Fischer, T. L. Johnson, S. E. Hygnstrom, and K. C. VerCauteren. 2010. Management of damage by elk (*Cervus elaphus*) in North America: a review. Wildlife Research 37:630-646.

Whitaker, P. B., and R. Shine. 2000. Sources of mortality of large elapid snakes in an agricultural landscape. Journal of Herpetology 34:121-128.

White, G. C. and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46 (Suppl.), S120 – S138.

Wolfe, A. K., P. A. Fleming, and P. W. Bateman. 2018. Impacts of translocation on a large urban-adapted venomous snake. Wildlife Research 45:316-324.

APPENDIX A

LETTER FROM IRB

MARSHALL UNIVERSITY.
www.marshall.edu

Office of Research Integrity

February 3, 2020

Allison Kelley
2107 7th Ave. Apt 616
Huntington, WV 25703

Dear Ms. Kelley:

This letter is in response to the submitted thesis abstract entitled *"The Effectiveness of Long-Distance Translocation of Eastern Diamondback Rattlesnakes (Crotalus adamanteus)."* After assessing the abstract it has been deemed not to be human subject research and therefore exempt from oversight of the Marshall University Institutional Review Board (IRB). The Institutional Animal Care and Use Committee (IACUC) has reviewed and approved the study under protocol #703. The applicable human and animal federal regulations have set forth the criteria utilized in making this determination. If there are any changes to the abstract you provided then you would need to resubmit that information to the Office of Research Integrity for review and a determination.

I appreciate your willingness to submit the abstract for determination. Please feel free to contact the Office of Research Integrity if you have any questions regarding future protocols that may require IRB review.

Sincerely,

Bruce F. Day, ThD, CIP
Director

WE ARE... MARSHALL.

One John Marshall Drive • Huntington, West Virginia 25755 • Tel 304/696-4303
A State University of West Virginia • An Affirmative Action/Equal Opportunity Employer